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14. ABSTRACT The scientific objective of this research was to understand the processes of small-scale sediment transport with the emphasis on the resuspension and vertical distribution of suspended sediment by turbulence, bottom boundary layer fluid-sediment interactions associated with large scale fluid forcing, and connections between spatial gradients in sediment flux and morphology change. Investigations during this grant period concentrated on the processes of transport related to vertical distribution of suspended sediment by turbulent forces generated by both surface-wave breaking and boundary shear flows.

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FIELD STUDIES OF SEDIMENT TRANSPORT IN THE NEARSHORE ENVIRONMENT, FINAL REPORT

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LONG-TERM GOAL

The long-term goals of this program were to improve our understanding of sediment transport processes in the nearshore. The interactions between physical forcing mechanisms and sediments lead to spatial and temporal variations in sediment flux, beach erosion, and deposition which drives changes in nearshore morphology. Thus small-scale studies of sediment-fluid interactions provide the link to ultimately understanding large-scale beach response.

SCIENTIFIC OBJECTIVES

The scientific objective of this research was to understand the processes of small-scale sediment transport with the emphasis on the resuspension and vertical distribution of suspended sediment by turbulence, bottom boundary layer fluid-sediment interactions associated with large scale fluid forcing, and connections between spatial gradients in sediment flux and morphology change. Investigations during this grant period concentrated on the processes of transport related to vertical distribution of suspended sediment by turbulent forces generated by both surface-wave breaking and boundary shear flows.

APPROACH

The overall approach was to conduct detailed field studies of sea surface fluctuations, velocity, velocity fluctuations and suspended sediments within the surf zone to investigate the relationship between fluid forcing and sediment response. Specifically, as part of the DUCK94 and SandyDuck experiments, we placed arrays of instruments in strategic locations in the nearshore zone and continually measured wave amplitudes, fluid velocity profiles, and suspended sediment profiles over extended time periods (days to weeks). Individual instrument arrays included electromagnetic current meters, a pressure transducer, and fiber optic backscatter sensors. Up to nine instrument arrays were deployed in coherent cross-shore and longshore patterns. The focus in the data analysis phase was on examining the vertical structure of the eddy diffusivity coefficient, as well as archiving and summarizing data for public release.

TASKS ACCOMPLISHED

The Ph.D. dissertation by Dr. Ogston was completed, which combines previous prototype-scale laboratory data and DUCK94 data to explore turbulent diffusion of sediment particles under broken and unbroken waves in the surf-zone.

Manuscripts have been published in peer-reviewed journals (see references below). A manuscript entitled "Effect of wave breaking on sediment eddy diffusivity, suspended-sediment concentration and longshore sediment flux profiles in the surf zone" has been submitted and is in publication (Ogston and Sternberg, in press).

Data archiving of the DUCK94 experiment data sets has been completed. DUCK94 data files have been transferred onto CD with intentional organizational structure for more efficient access to data for analysis. A summary of the entire data set (both summarized and raw) has been passed to Kent Hathaway of the USACE for public release.

Participation in the SandyDuck experiment carried out at the U.S. Army Corps of Engineers Research Facility at Duck, North Carolina. Nine instrument arrays were deployed in September and November of 1997.

RESULTS

Results from the DUCK94 experiment include characterization of an eddy diffusivity profile that incorporates the effects of both boundary shear and wave breaking. This eddy diffusivity profile was used to model suspended sediment profiles under unbroken and broken wave conditions. Under unbroken waves, suspended sediment profiles exhibit the influence of turbulence generated by boundary shear in a nearbed region of 2–3 times the thickness of the wave boundary layer (2–3 δ; typically 10-15 cm) above which very little sediment can be suspended. Under broken waves, the breaking-generated turbulence enables sediment to be suspended above the bottom boundary layer and is the major mechanism accounting for observed suspended sediment profiles. Turbulence intensity from breaking waves is scaled by breaker height and depth below the surface (i.e., sediment suspension is dominated by turbulence generated by wave breaking which penetrates into the water column, mixing particles upward as the turbulent bore progresses). Position across the surf zone relative to plunge point, appears to be of secondary importance. A procedure is presented for constructing vertical eddy coefficient profiles reflecting broken or unbroken wave conditions and using that profile to predict suspended sediment profiles and resulting longshore particle flux. Inclusion of turbulence generated by wave breaking in the surf zone can account for observed increases in the suspended sediment load and longshore sand transport, as much as 50% greater than predicted by present theories that use only turbulence generated by boundary shear flows.

These results represent concepts and analytical techniques that have not been included in surf zone sediment transport models to date. It is expected that these results, which are based on DUCK94 data (limited spatial extent), will be compared to SandyDuck results, which are more

extensive (extending across the surf zone). If these concepts and techniques are substantiated, they should have a significant impact on future modeling of sediment transport in the surf zone. The SandyDuck experiment provides an independent data set for testing of these concepts and will provide detailed longshore suspended sediment information to look at longshore coherence scales.

The archived DUCK94 data set includes hourly, 17-min average pressure, currents and suspended sediment concentration profiles over the experiment period. This data set was sent to Kent Hathaway at the USACE Field Research Facility to be incorporated in a web-based data server. The summary will allow the public to access processed data for so that an outside scientist can find a period of time of interest and request the raw high-frequency data. The entire raw data set will also be archived at the FRF.

PUBLICATIONS

Beach, R.A. and R.W. Sternberg (1996) Suspended-sediment transport in the surf zone: response to breaking waves. Continental Shelf Research 16: 1989-2004.

Ogston, A.S., C.R. Sherwood, and W.E. Asher (1995) Estimation of Turbulence-Dissipation Rates and Gas-Transfer Velocities in a Surf Pool: Analysis of the Results from WABEX-93, *Air-Water Gas Transfer*, eds B. Jahne and E. Monahan, AEON Verlag, p. 255-267.

Ogston, A.S. and R.W. Sternberg (1995) On the importance of nearbed sediment flux measurements for estimating sediment transport in the surf zone. Continental Shelf Research 15: 1515-1524.

Ogston, A.S. (1997) Influence of breaking waves on sediment concentration profiles and longshore sediment flux in the nearshore zone. Ph.D. Dissertation, Universtiy of Washington, Seattle, WA.

Ogston, A.S., and R.W. Sternberg (in press), Effect of wave breaking on sediment eddy diffusivity, suspended-sediment concentration and longshore sediment flux profiles in the surf zone. *Continental Shelf Research*.